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The Use of Plants In Iron Production: Insights from Smelting Remains from Buganda

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Introduction

Successful iron production requires the complex amalgamation of several inter-related specialist technologies (including charcoal production, tuyère production, furnace construction and so on), many of which incorporate a use of plant materials. However, despite the fact that plant use is an integral and necessary component of iron production, it is an aspect of smelting that has been rarely touched upon in the existing archaeological and archaeometallurgical literature. Dedicated studies of plant use within archaeometallurgy are even fewer in number (although notable exceptions include Mikkelsen 1997, 2003; Thompson and Young 1999).

In an effort to investigate this under-explored topic further, research was carried out into the use of plant material in some of the pre-colonial iron production industries of the former kingdom of Buganda, situated in what is now modern Uganda (Kiwanuka 1971; Reid 2003). This paper summarises the results of that research. The datasets for this study were derived from blocks of slag (which are generated as one of the waste products of iron production) that had been observed to bear numerous well-preserved, macroscopic plant impressions. Such slag blocks were recovered from a number of iron smelting sites from two regions within the former kingdom, as part of wider fieldwork run by Dr. Andrew Reid of UCL Institute of Archaeology. Ultimately, this study aimed to utilise the available plant data obtained from these sources in order to identify patterns in the selection and use of plants within the smelting technologies of these two regions, interpreting these patterns within the social context of the kingdom.

To obtain the necessary data from the slag remains, a novel methodology was specifically developed for this research. In order to gain optimal information on the plant impressions observed in the slag, non-destructive casts were taken of the plant impressions on-site in Uganda, using a polyvinylsiloxane dental gel. These casts could then easily be transported to London for further, more detailed microscopic examination. During the subsequent analysis, where possible the casts were used to identify the impressions to the level of plant family, and this data was then employed to reveal variations and uniformities in plant selection between the distinct areas of smelting. Additional information, drawn from local informants and ethnographic sources, as well as data concerning known vegetation patterns in the region, was also considered in order to generate hypotheses concerning raw material selection criteria, thereby facilitating a discussion of the social, ecological and technical factors involved in these iron production technologies.

African Iron Production and Plant Use

The spread of iron production and working throughout Africa in the First Millennium BC and First Millennium AD had a powerful transformative effect on the continent. It provided a new strong and tough material with which to create weapons and tools, thereby facilitating the clearance of forest and the intensification of agriculture as well as providing a new medium by which to fight and hunt. Due in part to this, iron production in sub-Saharan Africa has long been an area of archaeological interest (Childs and Killick 1993). Early studies tended to be heavily influenced by preconceptions of the ‘backwards’ and ‘pre-industrial’ nature of

African technologies, yet it has developed into a discipline that carries great academic importance. Today, there is a heightened appreciation of the sophistication and complexity of indigenous, pre-colonial iron production and working techniques, which are recognised to contribute valuable new perspectives to the more general field of world archaeometallurgy.

Undoubtedly, one of its most significant contributions to the wider body of archaeometallurgical knowledge has arisen from the opportunity for ethnographers working within Africa to record living iron production practices (e.g. Childs 2000; Haaland 1985; Reid and MacLean 1995; van der Merwe and Avery 1987 among many others). This has contributed towards the development of arguably a more complete understanding of both the physical, social and knowledge processes that make up these technologies, and have provided an opportunity to appreciate the full chaîne opératoires of many examples of iron production technologies within African contexts. Such ethnographic examples have demonstrated the relevance of the social contexts of iron production, and of the importance of giving more generous consideration to the supporting technologies, such as charcoal production and ore extraction, which are essential to the iron smelting process, and yet which are often overlooked.

Through these sources, the roles played by plant resources in the iron production process have been highlighted. Most obviously this is in the form of charcoal as fuel. However, ethnographic data has shown that plants also fulfil other vital roles, for example as part of ritual or symbolic activities prior to or during smelting (e.g. van der Merwe and Avery 1987), or through their incorporation into the furnace structure itself (e.g. Kagwa 1934; Roscoe 1911). Similarly, ethnographic examples have also indicated that the motivations that drive plant exploitation and utilisation are highly complex and vary widely, especially with regards to iron production (e.g. Childs 2000; Thompson and Young 1999; Tabuti et al. 2003). Trditions, such as restrictions of access to sacred groves or the necessity of negotiating with forest spirits before exploiting forest resources, plus a multitude of taboos concerning the procurement and use of certain plant species all are known to act as cultural regulators of plant exploitation in the Great Lakes region (Schmidt 1997; Tabuti et al. 2003).

Nevertheless, the means by which to examine these aspects of smelting technologies are somewhat limited. The most commonly encountered archaeological remains of smelting episodes are the blocks of slag that are left behind as waste products. Fortunately, these durable, rock-like remains provide valuable clues as to the environments, physical and chemical, in which they formed.

The solid-state ‘bloomery’ process of iron production was the method commonly employed across pre-colonial sub-Saharan Africa (Bachmann 1982; Miller and van der Merwe 1994). During this process, iron ore and charcoal are loaded into a lit furnace, with air introduced in a controlled manner through tuyères, or air-pipes. At a temperature of around 1150°C (below the melting point of iron) the gangue (unwanted rock minerals that occur in an ore deposit) begins to melt and physically separate from the iron oxides within the ore, which remain solid throughout. The reducing atmosphere within the furnace further chemically reduces these iron oxides to iron, which come together to form a spongy iron bloom, whereas the unwanted gangue materials cool and solidify to form slag (Figure 23.1). A successful smelt requires not only a high temperature and a controlled, reducing atmosphere, but also a means within the furnace structure to provide a way of physically separating the liquid slag waste from the solid metal bloom.

There are two major ways in which to achieve this separation. In the case of a slag-tapping furnace, the molten slag is drained away from the furnace periodically throughout the smelt, generally into a shallow pit to the side of the furnace structure. With a pit furnace, a pit is dug beneath the furnace shaft, which is packed with a rigid plant material. Straw, twigs, small branches and heather have all been documented as being used for this purpose (Mikkelsen 2003). This plant packing provides initial support for the furnace charge of ore and charcoal, and as the smelt progresses it becomes a receptacle for the molten slag, which runs through the fill structure and cools around the pit filling, leaving impressions of the packing material both on the surface of the slag and throughout it. In this way, tangible remains of the original packing material are preserved in the slag, presenting a unique opportunity to access some of the past plant use strategies employed in these technologies.

Archaeological Context of the Study

The Buganda kingdom is situated in the Great Lakes region of eastern Africa, and falls within the borders of present-day Uganda, lying on the north and northwest shores of Lake Victoria (Figure 23.2). It had become one of the most powerful and influential kingdoms in the region by the nineteenth century, growing in significance through a combination of banana plantation agriculture and military expansion from the seventeenth century. Iron was an important commodity needed both for weapons and for agricultural implements, such as the billhooks that were used to harvest bananas, Buganda's main food staple (Reid 2001). However, in the kingdom's formative years, a major strategic impediment was a lack of this crucial iron and the skilled labour capable of working this iron. Buganda responded to this need with a policy of expansion into neighbouring kingdoms, eventually encompassing the territories of Kyagwe to the east and Masaka to the west, areas which had both plentiful natural iron resources, and populations that were adept in the production and working of iron (Reid, R. 2002).

Archaeological survey between 2000 and 2003 pinpointed two main later Iron Age iron production locations in both of these areas: Kinanisi and Masaaba in Kyagwe district, and Bukeri-Kanywa and Birinzi 100km to the west in Masaka district (cf. Reid 2003). At the site of Kinanisi in Kyagwe, numerous slag clusters were found consisting of over a hundred individual slag blocks, each of which represents the waste materials from a single smelting episode. Two furnace bases were also excavated. Only 10km away at Masaaba, more slag clusters were found and a similarly high density of slag was recovered, although the slag was more brittle and tended to be more fragmentary. Further around the lakeshore in Masaka district, slag was recovered from two furnace bases that were excavated at Bukeri-Kanywa, and additional slag clusters were also encountered at Birinzi (Iles 2004; see Figure 23.2 for site locations). Archaeological and associated ceramic evidence suggests that all but one of these sites date to the eighteenth and nineteenth centuries; Bukeri-Kanywa alone is suggested to date to the sixteenth century (D. A. M. Reid pers. comm.).

On first inspection, the slag encountered at each of these sites appeared markedly different from each other in several ways. Not only were there differences in terms of slag flows, shape, size, density and brittleness, but variation was also noted in terms of the nature of the plant impressions visible on the slag surfaces. These plant impressions were often of such good condition that they showed detailed morphological features of the plant material – structures such as culms, inflorescences and leaves, as well as venation patterns and nodes (Figure 23.3). It was felt that these features might lead to the identification of the plants that the past smelters had chosen to use in these smelting episodes.

Applied Methodology

The initial challenge was to transform the plant impressions in the slag (individual blocks of which could weigh up to 200kg) into manageable and comparable samples for analysis. This was accomplished using a method adapted from one previously used to identify impressions of plant material in pottery (e.g. Abdel-Magid 1989; Stemler 1990; Fuller et al. 2007, Klee et al. 2000), which entailed casting the remains using a plastic impression material. One major advantage of this technique is that it allows the casts to be taken off-site to be studied using reflected light microscopy, whilst leaving the original impression undamaged.

Several casting options were considered, including latex- and silicone-based casting materials, but after much experimentation undertaken within the archaeobotanical laboratory at the UCL Institute of Archaeology prior to the 2003 field season, an addition-type polyvinylsiloxane dental gel was considered most appropriate (see also Fuller et al. 2007). Several factors rendered the other materials inappropriate in this instance: liquid latex rubber was found to shrink and distort whilst drying, resulting in non-diagnostic casts; silicone rubber was found to require a high level of accuracy in weighing the two addition parts, an important practical consideration when working in the field. Polyvinylsiloxane was considered the most suitable as it dries quickly and without major distortion, it requires no mould and it is simple to mix and use.

Several stages were required for successful casting in the field. Firstly, all the slag blocks selected for sampling (see below) were cleaned with water and brushes, and any plant impressions were inspected for their suitability for casting in terms of the preservation of characteristic features and morphology, and the extent of erosional damage. A paraloid consolidant (5% paraloid, 95% acetone) was then applied to the dry slag, and the two-part polyvinylsiloxane was mixed at a ratio of 1:1 and applied immediately to the selected impressions. After only a few minutes (although this was dependent on the ambient temperature and humidity), the cast was dry and able to be gently removed and washed of any residual dirt. If necessary, a second cast was taken from an impression if embedded dirt had resulted in a cast lacking in sufficient anatomical detail.

In total, nearly 500 samples were cast from selected slag blocks across the slag clusters. Samples were chosen on the basis of the clarity of impressions, and whether these impressions displayed clear morphological features. Importantly, they were also chosen to represent the proportions of different plant types present on a slag block, and detailed notes were taken of each slag block that was sampled from. The slag blocks that had been selected for additional metallurgical study were prioritised, in order to facilitate inter-disciplinary comparisons. The samples were then taken back to UCL Institute of Archaeology for analysis. In addition, several examples of local known plant species were collected, in order to be examined microscopically in conjunction with a small comparative collection. Although it was hoped that plant species would be classified through a detailed system based upon the identification of venation patterns specific to each species, unfortunately due to time restrictions and the lack of a fully comprehensive comparative collection, it was only possible to make identifications to the level of plant family. Initial classifications – based on features such as culm shape, venation patterns and node shape – were made to class (monocotyledon or dicotyledon), with monocotyledons further divided into several plant families: gramineae (grasses), cyperaceae (sedges) and musaceae (bananas) (Figure 23.4).

Summary and Discussion of Analytical Results

The results of this investigation (see Table 23.1) posed some interesting questions about the selection patterns and use of plant materials within the smelting technologies of the Buganda kingdom. Once analysis of the material had been completed, striking differences in the choices of plants used in each of the areas became apparent, which led to a recognition of three discrete technologies, each utilising distinct plant-selection or plant-use strategies.

Undoubtedly, the largest body of data was collected from Kinanisi in the Kyagwe region. Here, grasses were by far the most dominant plant material encountered, generally constituting about 90% of the samples that were positively identified, with sedges present at less than 10%. This appears to correspond with the modern vegetation landscape around Kinanisi, which is dominated by grass/savannah/forest mosaic, with limited patches of Cyperus papyrus swamp also accessible within a 7km radius. In addition to the identification of this overall trend, the sampling strategy from the individual slag-blocks at Kinanisi (which each represented a single smelting episode) allowed for the plant selection strategies to be considered on a smelt-by-smelt basis. By comparing the frequencies of plant species' between smelts, it was possible to see that there were high levels of continuity in plant choice from smelt to smelt. This uniformity in technological procedure was also reflected in the metallurgical analyses (cf. Humphris 2004; see also Humphris and Iles, in press).

The technological uniformity observed at Kinanisi was not unexpected. Due to iron's high material and cultural value, and the high cost of a failed smelt, many recent iron production technologies in the Great Lakes region have been seen to be steeped in ritual and tradition, which may serve to ensure technical repeatability and control over the process (de Barros 2000). Certain symbolic aspects of smelting that have been documented across sub-Saharan

Africa also appear to be present in several examples of recent iron production in Buganda, as conveyed by two written accounts that document Bugandan iron smelting in the early twentieth century. These accounts record non-technical features of these technologies, for example sexual prohibition and the attribution of gender to the different types of ore used, that were integral to the success of the smelts (Roscoe 1911; Kagwa 1934). Given this, it may be suggested that past smelters also had a variety of mechanisms in place that acted in keeping their materials and actions the same in every smelt they performed, in order to increase their probability of success. This is what may be seen reflected in the uniformity of the plant materials in use at Kinanisi.

The second body of data, from the sites in Masaka, presents a slightly different scenario of smelting technology and plant procurement to that seen in Kinanisi. The metallurgical analyses showed that the smelting technologies of Birinzi and Bukeri-Kanywa were technically very similar, with both sites utilising deep pit furnaces and using kaolinitic clays to produce highly refractory, greyish tuyères (Humphris 2004). This is in contrast to the shallow pit furnaces and reddish brown tuyères in evidence at Kinanisi, and also in contrast to the technology in Masaaba, which will be discussed in more detail below. Significantly less smelting waste was found at the two sites in Masaka district, and this is reflected in the number of casts taken from these sites. Unfortunately, the sample size from Bukeri-Kanywa was extremely limited, with only six casts taken from a single block of slag, which represented a single smelting episode. Many of the plant impressions on this slag were small and unsuitable for casting due to surface erosion of the slag block. However, it was still possible to see that both grass and sedge impressions were present. At Birinzi, in contrast to the evidence from Kinanisi, large sedges were the most dominant plant impression encountered, comprising about 75% of the sample set, generally stems, although numerous clear impressions of papyrus inflorescences were also present. This appears also to correspond well with modern vegetation patterns at both Birinzi and Bukeri-Kanywa, although there are surrounding grasslands, papyrus swamps are closer and more accessible than at Kinanisi.

Looking at the Kinanisi and Masaka data sets side by side, we see that although plant selection is likely to have been significantly influenced by local vegetation patterns, it is possible to suggest that selection criteria concerning the choice of plants used within the furnaces were not dictated by the availability of plant materials alone. Assuming that local vegetation patterns have remained relatively unchanged over the past few hundred years or so, both sedges and grasses are likely to have been available to the smelters at Kinanisi and in Masaka, yet in Kinanisi grasses were clearly preferred over sedges, whereas in Masaka, sedges dominated. Other influencing factors may have had an effect, although their nature, whether related to functional or cultural prerequisites, is difficult to ascertain. Certain types of plant may have been considered stronger to use or were easier to collect and carry. Alternative uses of some plants, such as grasses for thatching or papyrus for making mats, may also have shaped the value and application of certain plants in these regions. As mentioned previously, plant selection may also have been regulated by the need to avoid sacred groves, or taboos or restrictions concerning certain plants or other social issues of access. However, despite the differences in the proportions of different plant types, smelting practices in both of these areas, Kinanisi and Bukeri-Kanywa/Birinzi, were utilising the plant material in very similar ways, as packing material for pit furnaces.

The final set of botanical data returns us to Kyagwe district and the site of Masaaba, only 10km from Kinanisi. Here, the botanical results appeared markedly different from the other sites discussed above. In addition to a large percentage of grass impressions (roughly 65%), both Musaceae pseudostem impressions (c. 3%) and dicotyledenous leaf impressions (c. 20%) were also found on the surfaces of some of the slag fragments (see also Iles 2009). These findings were not initially understood. However, the metallurgical analysis of this material was able to discern that the slag from Masaaba had been part of a very different smelting process than had been seen at any of the other sites (Humphris 2004). At Masaaba, the macro- and micro-structures of the slag samples indicated that the slag had been tapped from the furnace, and had not formed within a furnace pit as at other sites. It appeared that this distinctive slag-tapping technology in use at Masaaba might also be linked to a significantly different approach to the use of plants.

At Masaaba plant matter was not required to fill or pack furnace pits, but plants clearly continued to play a valuable role. Roscoe (1911) describes the use of green leaves to quench the fire and protect the iron bloom as it cooled, in the iron smelting that he witnessed in Buganda at the turn of the last century. It is possible that the leaf and pseudostem impressions that are apparent at Masaaba may be a result of a similar use of plants. Whilst grasses may have been used to a certain extent as a packing and supporting material within the furnace body, it is possible that banana pseudostems were used to form bunds around the tapping pits in order to control the dangerous molten slag (D. A. M. Reid pers. comm.), whilst green, leafy branches might have been used to cover this liquid slag when it was outside the furnace, acting as a protective barrier for the smelters. Although the various suggestions as to why these plants were being used are interesting, clearly a much larger body of archaeobotanical data is required before the technological associations of such plant use are fully illuminated.

Conclusion

The botanical evidence presented here, supported by the complementary archaeometallurgical data, suggests that several distinct smelting technologies were active within the Buganda kingdom at the height of its influence in the eighteenth and nineteenth centuries. The method of production and plant-use seen in the pit furnaces and the resultant slag at Kinanisi contrasts greatly with the slag-tapping technology seen only 10km away at Masaaba. In Masaka district, at Birinzi and Bukeri-Kanywa, the types of plants being used as packing material for the furnaces were markedly different from those at Kinanisi in the Kyagwe region, yet they fulfilled a similar role. So, although differences in plant availability may have had some effect on different plant utilisation strategies, it is clear that the Buganda kingdom had several iron production traditions. This diversity is potentially related to the territorial expansion of the Buganda state at this time, which resulted in the assimilation of various groups into the kingdom, each utilising distinct, perhaps clan-based, smelting procedures to produce iron (Humphris et al. 2009; see also Iles 2011). In this way, the socio-political setting of the kingdom may have given rise to the existence of such diverse iron producing industries, as seen reflected both in the plant remains and in the metallurgical data.

The development and implementation of the methodology used here has been able to effectively highlight differences in plant use within iron production in Buganda. In conjunction with a second investigative technique, in this case archaeometallurgy, this methodology has provided insights into an aspect of iron production that is often overlooked. Unfortunately, the lack of an extensive comparative collection for this region, coupled with a restrictive time limit, meant that this project could not reach its full potential. To be of maximum use, the methodology needs to be refined further, to encompass a greater sample range and to facilitate the identification of plants to species level. Then it will be possible to comprehensively address questions of technological choice and plant utilisation, which will help to confirm and highlight further details of the pre-colonial metal producing technologies of this area of Great Lakes Africa. Nevertheless, I hope that this study demonstrates that even a basic identification of plant type is a worthwhile and valuable strand of archaeological investigation into iron technologies if a more complete understanding of the potential variation in these production processes is to be achieved.

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Figure 23.1. Schematic diagram showing the working of a pit furnace

Figure 23.2. The north-west shore of Lake Victoria, showing sites mentioned in the text

Figure 23.3. Plant impressions in slag: A) papyrus inflorescence, B) Musaceae pseudostem impression, C) dicotyledonous leaf impression, D) reed impression (photographs courtesy of D. A. M. Reid)

Figure 23.4. Casts of plant impressions: A) Musaceae pseudostem, B) sedge, C) grass, D) dicotyledon

Table 23.1. Table showing number of positively identified plants at each site